MAGNETO-OPTICS OF FERRITIN

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Ferritins, present in plant and animal cells, belong to the group of metalloproteides. The micelleous tertiary structure of these proteins allows iron accumulation in the form of hydratated oxides and phosphates of this metal. Thus ferritin is a large spherical macromolecular protein with iron compounds situated in the cavity created by a peptide shell. The refractive index of the macromolecular solution depends on the concentration of sodium ions in this solution. Therefore, measurements of classic light scattering, nonlinear light scattering and Cotton-Mouton effect have been carried out for 15 mM NaCl, 100 mM NaCl and water solutions of apoferritin and ferritin with different contents of iron ions at room temperature. The geometry of the molecule implies that it is optically isotropic. Such a macromolecule should not manifest magnetic anisotropy, however, in solution it shows the induced magnetic birefringence (Cotton-Mouton effect, called Majorana effect for macromolecules) and changes in intensity of the scattered light components. The analysis of the results obtained indicates a deformation of the linear optical polarizability induced in the biomacromolecule by a magnetic field as the main source of the magnetooptic phenomena observed. To characterize Mw, the molecular weight of the sample investigated, its Rayleigh light scattering together with refractive index increment was measured. From the static light scattering method, the depolarization ratio D_u, linear optical polarizability α and square of the anisotropy of the linear optical polarizabilities κ_α^2 as a function of protein concentration were estimated. Ferritin solutions were also studied by the dynamic light scattering. Diffusion coefficient indicated from these studies allows the estimation of the protein dimensions. The correlation functions obtained for the ferritin solution in the absence and in the presence of an external magnetic field were similar, suggesting the monomeric form of the macromolecule. This result indicates the lack of interactions (associations or aggregations) between the protein molecules due to a magnetic field. Light scattering in a magnetic field and the CM effects theoretically depend on the linear magnetic polarizability χ and nonlinear magnetooptical polarizability η. This observation suggests the diamagnetic behaviour of the ferritin biomacromolecule. Assuming the relevant theory describing the phenomena and taking into account the experimental data, the values of the anisotropy of the linear magnetic polarizability ($\chi_3 - \chi_1$), of the nonlinear polarizability η and of the nonlinear polarizabilities anisotropy κ_η were deduced. Different analysis can be performed by assuming the ferritin paramagnetism, postulated by other investigators. If ferritin had a permanent dipole moment μ, the positive sign of κ_α, the negative sign of ($\chi_3 - \chi_1$) and the value of μ would be deduced. When the samples of ferritin with different contents of Fe ions were studied in 100 mM NaCl, the dynamic light scattering studies revealed some amount of dimers and trimers in these preparations. The existence of these objects was connected with the chemical procedure of filling apoferritin with different amounts of iron. The Majorane effect measurements gave the angle of the polarization plane orientation as a function of the square of the magnetic field, $\beta = f(H^2)$. The linear dependence for all solution concentrations suggests the lack of interactions between proteins due to a magnetic field and support the findings obtained from dynamic light scattering. The values of molecular Cotton-Mouton constants as a function of Fe ion number per ferritin molecule were obtained. Because this constant does not depend on this number, the Majorana effect is assigned to the cavity structure in iron compounds.